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DETERMINATION OF THE FACTORS AFFECTING THE ACCEPTANCE OF COMPUTER SIMULATION RESULTS

THESIS

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"I can do all things through Christ which strengtheneth me."
Philippians 4:13

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"Wisdom is the principal thing; therefore get wisdom: and with all thy getting get understanding." Proverbs 4:7

Thomas Kent Wiggs

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Abstract

For the Air Force to continue developing and acquiring today's highly complex and costly weapon systems, it will have to depend more heavily on computer simulations to fill in where hardware is not available and actual testing cannot be performed. The usefulness of these computer simulations are limited, however, by the degree to which the results are accepted by managers. From a review of the literature, however, it would appear that no previous research has been performed to determine Air Force program managers' perceptions of the acceptability of computer simulation results. In light of that finding, the two objectives of this thesis were to identify the factors affecting the acceptance of computer simulation results by senior program mangers within AFSC/ASD and to determine the relative importance of the identified factors.

Because this research was exploratory in nature, the Delphi data collection technique was used. An expert panel of nine Air Force colonels completed the Delphi survey. The experts arrived at a list of sixteen factors that affect the acceptance of simulation results. Of these sixteen factors, only ten were said to have a "strong effect."

The conclusions drawn from the expert panel responses show that senior program managers are principally concerned about the simulation representing the "real world" and about the technical information incorporated into the model. The experts also expressed that the manager needs to know if the end user of the weapon system believes the simulation to be accurate. Several of the other factors included:

confidence in the individual performing the simulation, ability to assimilate any recommendations, acceptability of the model by the community that generally conducts simulations in the specialty area, confidence in the individual presenting the results, previous experience with simulations, superior's acceptance of simulation results, and managers' own insights and intuition.

DETERMINATION OF THE FACTORS AFFECTING THE ACCEPTANCE OF COMPUTER SIMULATION RESULTS

I. Introduction

General Issue

Within Air Force Systems Command (AFSC), program managers are responsible for the acquisition and testing of many new weapon systems for the US Air Force (USAF), such as the Advanced Cruise Missile (ACM), the Advanced Technology Bomber (B-2), the Short Range Attack Missile II (SRAM II) and others. The operational commands and the Air Force Operational Test and Evaluation Center (AFOTEC) are responsible for confirming that the using command's needs are truly being met by the systems being acquired. Ideally, the evaluation of the systems would be performed through the use of system test data only. However, due to cost, time, safety and other constraints, this cannot be done. To cover all areas of the evaluation, computer simulation is used to supplement system testing. The value of these computer simulations is dependent on managers acceptance of the simulation results.

Problem Statement

In this time of decreasing military budgets and increasing weapon system complexity/cost, the military needs to use all of its resources in the most efficient way possible. If hardware testing was the only method of determining a system's capabilities and dependability, this nation's war fighting capability could be greatly reduced due to insuf-

ficient, inaccurate or misleading system data. This problem of uncertain system information can be partially avoided through the use of simulation during weapon system acquisition. Simulation can be used in the acquisition of major weapon systems to assist in design, test and managerial decision making. The usefulness of the simulation results are limited, however, by their accuracy and their acceptance by management. It is the area of acceptance of computer simulation results by program management that is addressed in this research.

A review of the literature indicates that no attempt has been made to measure program manager's current attitudes toward the use of computer simulations nor has the significance of various factors on the usefulness of simulation results used by Air Force program managers been measured. In fact, it appears that no attempt has been made to determine the factors that affect the acceptance of computer simulation results by program managers.

Once the factors affecting the acceptance of computer simulation results have been characterized, then data can be collected which will show the current level of acceptance of simulation results by program managers. This current level of acceptance data can then be used to pinpoint areas needing attention so that the acceptance of simulation results can be improved.

Research Objectives

The main objective of this study was to identify the factors that affect the acceptance of computer simulation results. A second objective was to determine the relative importance of these factors to the program managers.

Research Questions

To meet the research objectives, the following questions were posed:

1. What are the factors that affect the acceptance of computer simulation results used by senior program managers within AFSC/ASD?

2. What is the relative importance of the factors identified to the senior program managers within AFSC/ASD?

Scope

This research was limited to senior AFSC program managers within ASD. For the purpose of this research, the senior program manager was defined as an Air Force officer of the grade O-6 or above who is or has been the program manager of an Air Force weapon system acquisition effort. These senior program managers possess a Duty Air Force Specialty Code of 0002, 0016 or 0029. This classification was used so that only those individuals who had been determined to be "top managers", experts, would be surveyed as part of this research.

The determination of the factors affecting the acceptance of computer simulation results was based on the purposive judgment of expert senior Air Force program managers. It is possible that a survey of a different group of experts ould result in a different set of factors.

Background

The use of simulation in program development began to be noticed during World War II. John Von Neumann and Stanislaw Ulam from Los Alamos Scientific Laboratory used Monte Carlo simulations to solve neutron diffusion problems. In the 1960's, computer modeling and simulation began to be included in college and university courses (16:1).

In the past several years, computer simulation has experienced extensive growth. In fact, in March 1989 the Department of Defense (DOD) presented the Critical Technologies Plan to Congress, that identifies the 22 most essential technologies to the "long term qualitative superiority of US weapon systems" (15:25). This plan presented simulation and modeling as number six. Computer simulation has several advantages over real experiments. Simulations cost less; they only take seconds to execute instead of weeks or years; exact replication can be achieved; and experiments can be performed that would otherwise be too dangerous (18:8).

Computer simulation normally involves three main steps. The first is to characterize the system to be modeled or "building the theory". In this step the inputs and the outcomes must be determined, the internal operation of the sub-systems must be known and any limitations of the system must be established (21:174).

The second step is the transformation of the system into a model (21:174). One of the most common methods of doing this is through the use of flow charts. Flow charts allow for a smooth logical order of events to be described easily and allows for easier verification of software coding later in the process.

The third step is the conversion of the flow chart (model) into a computer program. Usually a higher level programming language, such as FORTRAN, or a specialized simulation language, such as SLAM II, is used (21:174).

In addition to creating the computer program, the model must be proved to be a valid representation of the original system. The process of determining validity takes place in all three steps: the characteri-

zation, the flow chart, and the computer programming (21:178). Care must be taken not to assume the final program is valid on the basis of only validating the first two steps, as Glazer says "findings from such simulations, while internally valid, may not be totally externally valid due to the multitude of complicating factors present in the real world" (9:546). Robert Sargent states: "To obtain a high degree of confidence in a model and its results, comparison of the model's and system's input-output behavior for at least two different sets of experiment conditions is usually required" (20:36). The importance of validating the model cannot be assumed to be of little importance; it is one of the most important actions that must be taken before a simulation can be declared of any value.

The modeling and programming steps are only preparation for the true simulation effort. Once the model has been validated, it can then be used to conduct "trial-and-error experiments" (12:56; 18:5). Two examples of these experiments are hardware system development and war gaming. In these examples, the user of the model is able to perform simulations using a variety of system characteristics. With each successive simulation, the user is able to refine the system characteristics allowing progress to be made toward a predetermined end goal. Once the predetermined end goal is reached, the system characteristics can be passed to the next stage of development. In the case of hardware system development, the next stage might be hardware fabrication or the next stage could be an integrated war plan in the case of a war gaming simulation (12:56; 18:5).

Simulation has been very important in the development of new hardware systems. One good example is the use of Computer-Aided Engineering

(CAE), which has increased flexibility in design for both the managers and the engineers. The managers are able to monitor progress of the system with a high degree of accuracy and the engineer can "stress and test" the design throughout the design process (1:13,42).

War gaming is a simulation in which models from multiple offensive and/or defensive weapon systems are integrated with a model that characterizes a wartime environment. The Army is using ARTBASS, a battlefield simulation, to train battalion commanders (12:58). The Air Force is developing a network of computers that will simulate the Strategic Defense Initiative (SDI) command, control and communication system reaction to a nuclear attack (2:18).

All of the efforts outlined in the description above is fine in and of itself; however, this information does not address how willing management is to truly accept and use these computer simulations. It really does not matter how much effort goes into the development and validation of a simulation if management is not willing to use it. An exploration of the literature addressing this issue of managerial acceptance of computer simulation results indicates little or no research has been done in this area.

Robert Sargent points out that the primary factor in determining an individual's confidence in simulation is the degree of validation that has been performed. Sargent also says that verification of correct software coding affects the confidence in simulation (20:33,38). William Morris, in his writings on managerial acceptance of industrial engineering efforts, agrees that scientific validity is one of the best criteria to use for the acceptance of recommendations. However, he goes further to suggest that there are a number of other factors that are

considered. Morris states that managers also depend on: personal insights and intuition, an understanding of the technical aspects of the recommendation, acceptance of recommendations by the manager's superiors, acceptance of equivalent recommendations by manager's peers, the degree to which the manager is able to assimilate recommendations, manager's confidence in the individual presenting the recommendations, manager's confidence in the individual performing the study, the degree (magnitude) of effort used to develop the recommendations, cost of obtaining recommendations, the manager's previous experience with that type of study, and the skill used in presenting the recommendations to the manager (14:16-19). In addition to these factors, there is some reason to believe that formal education courses in computer simulation could have some effect on the acceptance of their results (7).

Key Terms and Definitions

Computer simulation is a process of using a mathematical/logical representation, model, of some real world system that is manipulated to perform near realistic experiments on a computer (3:7; 16:6; 18:5; 19:6; 21:173-174).

Verification is the process of confirming that the computer software that comprises the model executes as intended. In verification, there is no attempt to compare simulation results to the system being modeled. (3:7,13; 16:67; 20:33,35)

Validation is the process of comparing the results of the computer simulation to the real world system to determine how well the real world system is replicated (3:7,13; 16:67; 18:9; 20:33). There are numerous types of validation. Some of the most common types are: expert opinion,

comparison to other models, event validity, extreme-condition, face validity and historical methods.

An expert is an individual who has extensive experience and is prominent in an area of study.

Overview

This chapter outlined the Air Force's need for simulation and a brief history of computer simulation. The problem to be addressed, the research objectives and the research questions were presented as well as a review of the related literature. As part of the literature, a list of factors, presented by William Morris, affecting the acceptance of industrial engineering recommendations was outlined.

The following chapters describe the research in more detail. Chapter II presents the research plan for obtaining the desired data from senior Air Force program managers, while Chapter III covers the research findings and data analysis performed. In Chapter IV, the research is summarized and recommendations for future research and application of this research are outlined.

II. Methodology

During the review of literature, no previous research was found which addressed the weapon system program manager's perceptions of computer simulation results. However, William Morris did discuss factors affecting the acceptance of industrial engineering work (14:16-18). As this is the first attempt to evaluate a program manager's perceptions of the utility of computer simulation results in weapon system acquisition decisions, an exploration approach to research was used (8:62). This exploratory research focused on the determination of factors affecting the acceptance of computer simulation results by senior Air Force acquisition managers. The Delphi data collection technique was used to identify the factors using Morris' factors as the foundation to begin research.

The factors that were used as the foundation in this evaluation were: understanding of the technical information used in simulation models, degree to which a computer model represents the "real world", verification of correct software coding, agreement with manager's insights and intuition, acceptance of simulation results by superiors, acceptance by other program managers, degree (magnitude) of effort used in developing the simulation model, manager's ability to understand results, manager's confidence in the individual presenting the results, confidence in the individual performing the simulation study, cost of obtaining simulation results, manager's previous experience with simulation studies, skill used in presenting the simulation results, and formal education courses in computer simulation design and use.

Delphi Technique

The Delphi technique is simply a set of procedures "used for the elicitation of opinions with the objective of obtaining a group response of a panel of experts" (4:3; 5:v). This technique is a qualitative method that places the emphasis on informed judgment. The technique is based on the old adage "Two heads are better than one," especially in a situation where exact knowledge is not available. Norman C. Dalkey, one of the original developers of the Delphi technique, said that

> the Delphi procedure is one of the most efficient I know for "uncovering" the implicit models that lie behind opinions in the "soft" areas. One of the most valuable side-products of a Delphi exercise concerned with strategic bombing was the skeleton of a model which was later fleshed out in great detail. (6:9)

Traditionally, group decision making has resulted in more accurate conclusions than individual decisions. This is a result of having a greater amount of information available because of having more individuals' experiences and that more complex problems can be addressed because there are more individuals to consider the problem. However, there has been several major disadvantages identified in connection with face-to-face panels or committees. First, there is at least as much misinformation in a group as there is for an individual. Second, the existence of strong peer pressure to agree with the majority. Next, the goal of the group changes from its primary intent to one of finding an answer that will not offend anyone, even though no individual member may agree strongly either. Another problem is that the minority opinion may overpower the rest of the group by its strong vocalization and the repetition of the arguments. Face-to-face panels also have a problem with being vulnerable to the influence of "dominant individuals." The

sixth disadvantage is that individual members of the panel may have vested interests in the outcomes of the discussions which may cause the individual to ignore all facts and logic, and concentrate solely on winning the argument. Finally, the entire panel may share a common bias. This common bias is counter to the intent of this technique which is to have individuals with different biases causing a canceling effect. (13:15-16). The Delphi technique has three features that attempt to counter the negative effects of face to face panel discussion: anonymity, iteration with controlled feedback, and statistical group response (5:16; 13:16).

The first feature, anonymity, is achieved through the use of questionnaires or computer communication. This feature reduces the effect of dominant individuals. The iteration with controlled feedback feature allows the group to move toward consensus through iterations, rounds, of expressed opinions with a group moderator that assures that only relevant information is made available through the feedback process. Statistical group response generally includes a presentation of the mean and median of the panel's opinion and the degree of spread from the mean. This feature assures that all opinions are represented in the response, not just the majority opinion. These features have, in fact, been found to correct for many of the problems connected with collecting expert opinion in a classical panel or round-table forum (5:16; 13:16-17).

Another advantage of the Delphi technique over face-to-face discussions is that it is more accurate. Experiments performed by both R. Campbell and Norman Dalkey show that information resulting from the use of the Delphi technique are more likely to be correct than those result-

ing fr a face-to-face discussion. Campbell's experiment involved the use of a group of graduate students who were asked to make short-range economic forecasts from a set of supplied data. The students were divided into groups that used the Delphi and those who used any type of "free communication" desired. The result of the experiment was that the Delphi forecasts were more accurate in 13 cases, after the fourth round and the non-Delphi groups were more accurate in only two cases.

Dalkey used a group of ten graduate students who were divided into two groups. In this experiment, the face-to-face discussion group was given specific instructions as to the procedures that were to be used. The Delphi group used the Delphi procedures. The result of Dalkey's experiment was that the Delphi group was more accurate in 13 cases and the face-to-face group was more accurate in 7 cases (4:7-12; 5:21-23). One author stated:

> Dalkey's findings show that the group process in Delphi does an efficient job of extracting information from a panel as compared with face-to-face interaction. While none of these findings can "validate" a Delphi forecast, taken together they indicate that when it is necessary to use expert opinion, Delphi is a good way of getting it. (13:23-24)

The Delphi technique has not been developed without its critics. H. Sackman charged that its biggest problem is that the results of a Delphi exercise are not verifiable. He says this is a major violation of the rules of scientific research. Sackman also had other criticisms including: lack of documentation of experience and qualifications of the experts, biased results due to respondent dropout, the time required of the participants to complete all rounds, and encourages "snap judgments" (sackman:13-22). Most of the Delphi studies that Sackman used to develop these criticisms were of the forecasting type. Since this

research does not involve forecasting and focuses on the determination of factors, these criticisms will have little or no impact on the conclusions drawn from this use of the Delphi technique.

The first step in implementing the Delphi technique is the selecting of panel members. This step is probably one of the most difficult and most critical portions of the Delphi technique. The first problem is defining what an expert is in the technical area of research. Then the next problem is finding individuals who are "true" experts in that field. Another problem is selecting a panel from the available experts that will be unbiased and represent a cross section of available thought on the subject being addressed (4:3-4: 13:26-29). Martino says "It cannot be emphasized too strongly that choosing the panel is the most important decision the panel moderator will make, and considerable effort in making a good selection is fully justified" (13:29). Authors Jones and Twiss recommended that the number of experts included on the panel should be between 10 and 50. It was pointed out that less than 10 panel members may limit the availability of varied backgrounds and the accuracy of results (11:229).

Once the questionnaire has been developed and pretested for accuracy and validation of statements, the first round can be initiated. Accompanying the first round should be a clear statement of the Delphi procedure. After the responses are returned, medians should be calculated for each question and any comments that were returned should be reviewed for relevance. The medians and relevant comments are then incorporated into the survey and returned to the panel members. In round two, the panel members are asked to consider their responses in relation to the median response and the comments provided, and make any changes and

comments that they feel are appropriate. This process of rounds is continued until consensus is reached or stability is achieved on at least 70 percent of the questions with a minimum of two rounds being executed. Consensus is defined as at least 50 percent agreement within the panel and stability is achieved when no further change in opinion is expressed. Once consensus or stability is observed, the opinions expressed in the final round are regarded as the panel's conclusions (4:4-6; 13:18-20).

Mean and median calculations are used in the analysis of the survey results. These calculations are used as a measure of central tendency for the data. "The median of a set of measurements is defined to be the middle value when the measurements are arranged from lowest to highest" (17:33). The median of an odd number of measurements is simply the middle value. The median of an even number of measurements, however, is the average of the two middle values. "The arithmetic mean, or mean, of a set of measurements is defined to be the sum of the measurements divided by the total number of measurements" (17:35).

Population

Since the focus of this research is the determination of factors affecting the acceptance of computer simulation results by weapon system program managers, an expert must be experienced in the use of simulation results in decision making. In addition to decision making, the individual must also be in a position of responsibility requiring a determination of acceptance of the simulation results. Within the Air Force, a position having these characteristics is that of program man-

ager. Therefore, the sample of experts was drawn from a population of program managers in the acquisition of weapon systems for the USAF.

Sampling

For the purposes of this research, it was decided that experts in decision making, as it applies to Air Force weapon system acquisition, would be defined as officers of the grade O-6 or above with a Duty Air Force Specialty Code (DAFSC) of 0002, 0016 or 0029. These DAFSCs are used to describe individuals who have the experience and knowledge required to direct the Air Force's most important programs. It was decided to draw panel members non-randomly from AFSC/ASD because of the quality of personnel and their proximity to AFIT. It was also assumed that, as a whole, these personnel were characteristic of their peers assigned throughout the Air Force acquisition community. A list of 25 individuals possessing the necessary characteristics was received from the personnel office at ASD. From the 25 individuals listed 20 O-6s were selected to participate in the research. It should be noted that during the execution of this research one of the panel members was promoted to Brigadier General.

Delphi Survey Development

The survey was developed using the factors outlined by Morris and was scored so that a five point Likert scale could be used. Ample space was provided for comments.

Pretest. A completed survey was pretested by four members of the AFIT School of Systems and Logistics graduate faculty. Of these four members, one is an instructor of "Research Methods" and is very knowledgeable in the Delphi technique, one has used the Delphi technique in

previous research and has worked within a SPO organization, the third is experienced in the use of computer simulations and the interpretation of their results, and the fourth is familiar with general SPO operations and administrative procedures. Comments provided by these individuals were incorporated into the survey before the first round was sent out. The individuals who took part in the pretest did not participate in the actual Delphi exercise.

<u>Round One</u>. The first round Delphi survey included 8 demographic questions, 16 questions pertaining to the factors outlined by Morris, and an open ended request for comments and additional factors that should be considered. The first round Delphi survey is displayed in Appendix A. Of the 8 demographic questions, questions 7 and 8 were designed to eliminate from the exercise those individuals that had not had any exposure to computer simulation studies or the use of simulation results. Questions 10 through 23 used a five point Likert scale to measure the expert's responses. Each expert was asked to respond by selecting the descriptive term that most accurately reflected their judgment on each question. The Likert scale used is depicted in Figure 1.

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

Fig. 1. Likert Rating Scale

The Likert scale was selected for use in this research because of several advantages over other methods. This scale is easy and quick to construct, and is easy to interpret allowing for maximum participation

by panel members. The Likert scale is "probably more reliable" and provides a greater volume of data than other similar scales (8:255-258).

Question 24 was designed as an attempt to rank order the 14 factors in order of importance. A column was also provided labeled "Personal Knowledge Required" in an attempt to determine which of the factors were used personally by the program managers and which they believe were the responsibility of a lower level manager.

The wording for the cover letter and the survey instructions to the panel members were taken from Captain Ralinda Gregor's 1988 thesis (10).

The participants were asked to return the surveys in ten days. Telephone followup calls were made after three weeks to those panel members who had not responded. At the end of the fifth week only one additional survey had been received. This resulted in a total of 16 surveys being returned, an 80 percent return rate. Of the 16 returned surveys, 7 panel members stated that they had had no exposure to the use of simulation results on the job. This yielded 9 panel members to take part in the second round of the exercise.

Round Two   The second round Delphi survey included all factors, even if consensus had been reached on the first round. This was done to allow the panel members an opportunity to see the first round results and make any comments or changes desired. The panel's ratings were fed back in the form of frequency counts for each descriptive term, as well as any comments that had been made for each question. Two additional factors were suggested as part of the first round. These two new factors were included as new questions in the second round and panel members were asked to determine where within the prioritized list of factors, round one question 24, they should be placed.

In this research, the tool used to feed back an earlier round's results was a frequency distribution of the responses, not the standard mean, median and interquartile range (IQR). This was done in order to provide the most accurate feedback possible. This also avoided the problem of the panel members thinking that a designator 1 through 5, being assigned to the descriptive terms, was in some way showing an order of desirability.

The second round Delphi survey is displayed in Attachment B. The wording for the second cover letter and the survey instructions to the panel members were taken from Captain Ralinda Gregor's 1988 thesis (10).

Telephone followup calls were made after two weeks to those panel members who had not responded. At the end of the fourth week one additional survey had been received. This resulted in a total of eight surveys being returned, an 89 percent return rate.

Summary

This chapter provided a synopsis of the process used to develop a profile of factors affecting the acceptance of computer simulation results. A description of the Delphi data collection technique was provided as well as an analysis of the population and sample. It was explained that Morris' list of factors was used as a foundation for the round one survey and that 15 responses out of the 20 surveys distributed were received. Only 9 of the 15 responses were used in the second round of the exercise. The next chapter presents and analyzes the data obtained in the research.

III. Findings and Analysis

This research dealt with determining the factors affecting the senior Air Force program manager's acceptance of computer simulation results. Chapter II described the research plan, including a description of the Delphi data collection technique. This chapter presents a demographic characterization of the panel members who participated in the Delphi exercise and the Delphi results.

Delphi Panel

The first round Delphi panel consisted of nine colonels representing 61 years of combined SPO experience. The panel also contributed 36 years of combined computer simulation experience. During the second round of the Delphi survey, one of the colonels did not respond reducing the years of combined SPO experience to 59. All panel members are presently assigned to AFSC with six of the participants having previously been assigned to Strategic Air Command (SAC) or Tactical Air Command (TAC). Four of the officers had been assigned to either Headquarters Air Force (HAF), United States Air Forces in Europe (USAFE) or the Pacific Air Forces (PACAF). Three individuals have been in AFSC for their entire Air Force career.

In the area of educational background, seven of the members received their bachelor's degree in engineering, with the two remaining possessing undergraduate degrees in business administration. However, only four of the panel members earned graduate degrees in engineering while six earned degrees in either business administration or program management (note that one individual had earned masters degrees in both

engineering and business administration). One panel member does have a doctorate in engineering. Interestingly, only one of the panel members had ever taken any formal computer simulation education courses and even then, he only had taken two courses. Two of the nine had participated in the development of at least one computer model and all had used computer simulation results in decision making.

Delphi Survey

The round one survey consisted of 24 questions, including nine demographic questions, fourteen Likert scale items and one relative importance, ranking, question. The round two survey contained seventeen questions. Sixteen Likert scale questions, two of which had been added as a result of the first round, and one relative importance, or ranking, question. The Delphi exercise was terminated at the conclusion of the second round.

Round One Twenty round one surveys were sent out. Of the 20 surveys distributed 16 were returned. This yielded an 80 percent return rate, however seven individuals disqualified themselves as experts in the use of computer simulation results. Follow-up telephone calls were made to the remaining four survey recipients; however, due to temporary duty assignments (TDYs), scheduled leave or other reasons, these individuals did not complete the survey. A telephone call was made to one of the panel members to clarify his demographic data.

A summary of the panel members' responses to the first round Likert scale questions is shown in Table 1. Each term in the Likert scale was assigned a numerical rating with 1 being assigned to "No Effect" and 5 being assigned to "Very Strong Effect." A rating of 0 was assigned to a

Table 1. Likert Responses -- Round One Delphi Survey

Factor	Ratings 5	4	3	2	1	0	Mean	Median	Personal Knowledge Required
Understanding of technical information	1	6	2	0	0	0	3.83	4	100%
Degree represents "real world"	4	5	0	0	1	0	4.44	4	89%
Code verification	1	2	3	3	0	0	3.11	3	56%
Agreement with personal insights/intuition	3	4	2	0	0	0	4.11	4	50%
Supervisor acceptance	1	4	4	0	0	0	3.67	4	50%
Other program managers acceptance	0	1	4	4	0	0	2.67	3	33%
Degree (magnitude) of development effort	0	1	3	3	2	0	2.33	2	56%
Ability to understand recommendations from results	3	5	0	0	0	1	4.38	4	11%
Confidence in individual presenting results	2	6	1	0	0	0	4.11	4	22%
Confidence in individual performing simulation	2	5	1	1	0	0	3.89	4	33%
Cost of performing simulation	0	0	4	3	2	0	2.22	2	11%
Personal previous experience	0	5	4	0	0	0	3.56	4	11%
Skill used in presenting results	0	3	6	0	0	0	3.33	3	0%
Formal education courses	0	1	3	5	0	0	2.56	2	89%

response of "No Opinion/Don't Understand." This summary includes the calculated mean and median for each factor. It also includes the percentage of respondents that indicated they required personal knowledge of the information as opposed to being dependent on individuals lower in the organization for the knowledge. The last question of round one called for the expert to rank order the factors, with "1" being the most important. The ranking is shown in Table 2 and includes, for comparison purposes, the calculated mean and median values, from Table 1, for each of the Likert questions. A determination of consensus was not made after the first round since a minimum of two rounds were required. Comments made by the panel members are listed in Appendix C.

Table 2 shows that seven of the factors clearly had a "strong effect", a median of 4, on the manager. An eighth factor with a median of "4" was also identified; however, it was ranked last as part of the ranking exercise. This difference brings into question the accuracy of either the ranking or the Likert response of that last factor. It would appear that a combination of small sample size, extreme views and negative connotation of "intuition" being used by top management in decision making led to this factor receiving a low initial ranking while still having a "strong effect" on the Likert scale. The high Likert median appears to be an accurate measure of this factor's effect. This can be traced to research which shows that the lack of information, uncertainty attributed to information, and conflicting goals of an organization force the manager to depend on "personal insights and intuition" to arrive at good decisions (22). One of the experts said that "Unfortunately, we all suspect the model builder, because simulations have been used for political purposes; thus, and again unfortunately, simulations

Table 2. Ranked Factors -- Round One Delphi Survey

Rank	Likert Median	Likert Mean	Factor
1	4	4.44	Degree to which model represents the "real world"
2	4	3.83	Technical information incorporated in the computer model
3	4	3.89	Confidence in individual performing simulation
4	4	4.11	Confidence in individual presenting results
5	4	4.38	Ability to assimilate recommendations
6	4	3.56	Previous experience with simulations
7	4	3.67	Superior's acceptance of simulation results
8	3	3.11	Verification of correct software coding
9	2	2.33	Degree (magnitude) of effort developing results
10	2	2.22	Cost of getting results
11	3	2.67	Other program managers' acceptance of simulation results
12	2	2.56	Formal education courses in computer simulation
13	3	3.33	Tact used in presenting results
14	4	4.11	Managers' insights and intuition

that counter our intuition are often rejected." The remaining six factors were rated as approximately equivalent in importance. It appears that the factors ranked numbers one through five have equally strong effect on the managers acceptance of simulation results.

Of the fourteen factors in the first round survey, six were related to the manager's own perceptions. The eight remaining factors pertain to knowledge required by managers to make decisions. These eight factors are listed in Table 3. In round one, the experts were asked to mark if they believed managers required personal knowledge of any of these factors. Each of the top five factors in Table 3 received a 50 percent or better response. These top five factors were also rated as having a "strong effect" by the Likert evaluation. The remaining three factors received less than a 50 percent response when the experts were asked about personal knowledge requirements and had less than a "strong effect" Likert median. These results show that experts believe that managers require personal knowledge of those factors that strongly affect their decisions. Additionally, the experts believe that the manager expects his subordinates to monitor the less important factors as indicated by the lower Likert median and ranking. In other words words, managers need to have more personal knowledge about the important factors than they do about the factors which have little effect. so that the manager can focus on the more important issues.

A number of very good comments were received as part of the first round responses (Appendix C). Several of these comments are provided here. One expert made a statement in connection with a manager's understanding of the technical information used in simulations that "too often managers believe the data is being manipulated to get an answer if

Table 3. Ranked Factors Requiring Manager's Personal Knowledge

Rank	Personal Knowledge Required	Factor
1	89%	Degree to which model represents the "real world"
2	100%	Technical information incorporated in the computer model
7	50%	Superior's acceptance of simulation results
8	56%	Verification of correct software coding
9	56%	Degree (magnitude) of effort developing results
10	11%	Cost of getting results
11	33%	Other program managers' acceptance of simulation results
13	0%	Tact used in presenting results

they don't understand the detail." Another expert pointed out that a model's ability to represent the "real world" is not always very important. He said "many times we can only guess at 'real world' but the simulation is still valuable in choosing between alternatives...." Two of the more significant comments were recommendations of additional factors to be included in the second round that had not been included in William Morris' list, described in Chapter II. The first recommended factor was "acceptance by user [the organization for which the weapon system is being procured] of the simulation representing the real world." The second additional factor recommended was "Acceptability of the model by the community that generally conducts simulations in the specialty area." These factors were added to the round two survey.

Round Two The round two survey was sent to each of the nine panel members remaining after the first round. Eight of the nine returned the

survey resulting in an 89 percent response rate. The one individual that failed to return the survey was contacted. He stated that he had not understood that the package was the second round survey and had thrown it away thinking that it was another copy of round one. He also said that he did not have the time to complete another survey and asked to be removed from the exercise.

As part of the second round survey, each panel member was asked to respond to the same fourteen Likert scale questions plus the one additional question for each of the two new factors introduced as a results of the first round comments. Each of the original fourteen questions included a statement of his/her first round response, a frequency distribution of all first round responses and any comments which had been made. This information allowed the individual to compare his/her responses to those of the other members of the panel. A summary of the second round Likert questions including calculated mean, median and statement of consensus for each factor are shown in Table 4. The data derived from the rank ordering question was included in the second round survey. The mean of the first round responses for each factor was used as the basis to rank and reorder the factors. This reordered list of factors was presented to the panel members for re-evaluation; however, their first round responses were not included. The panel members were also asked to place the two new factors into the revised ranking. The revised ranking is shown in Table 4 and includes the calculated mean and median from the Likert questions, Table 5, for each factor. Comments returned with the second round are listed in Appendix C, along with the first round comments.

Table 4. Likert Responses -- Round Two Delphi Survey

Factor	Ratings 5	4	3	2	1	0	Mean	Median	
Understanding of technical information	1	5	2	0	0	0	3.81	4	Consensus
Degree represents "real world"	2	6	0	0	1	0	4.25	4	Consensus
Code verification	0	2	3	3	0	0	2.88	3	
Agreement with personal insights/intuition	3	4	1	0	0	0	4.25	4	Consensus
Supervisor acceptance	1	4	3	0	0	0	3.75	4	Consensus
Other program managers acceptance	0	1	4	3	0	0	2.75	3	Consensus
Degree (magnitude) of development effort	0	1	3	3	1	0	2.50	2.5	
Ability to understand recommendations from results	1	7	0	0	0	1	4.25	4	Consensus
Confidence in individual presenting results	1	7	0	0	0	0	4.13	4	Consensus
Confidence in individual performing simulation	1	6	0	1	0	0	3.88	4	Consensus
Cost of performing simulation	0	0	3	4	1	0	2.25	2	Consensus
Personal previous experience	0	5	3	0	0	0	3.63	4	Consensus
Skill used in presenting results	0	3	5	0	0	0	3.38	3	Consensus
Formal education courses	0	0	3	5	0	0	2.38	2	Consensus
Acceptance by user	0	6	2	0	0	0	3.75	4	Consensus
Acceptance by simulation community	0	7	1	0	0	0	3.88	4	Consensus

Table 5. Ranked Factors -- Round Two Delphi Survey

Rank	Likert Median	Likert Mean	Factor
1	4	4.25	Degree to which model represents the "real world"
2	4	3.81	Technical information incorporated in the computer model
3	4	3.75	Acceptance by user of the simulation's ability to represent the "real world"
4	4	3.88	Confidence in individual performing simulation
5	4	4.25	Ability to assimilate recommendations
6	4	3.88	Acceptability of model by the community that generally conducts simulations in the specialty area
7	4	4.13	Confidence in individual presenting results
8	4	3.63	Previous experience with simulations
9	4	3.75	Superior's acceptance of simulation results
10	4	4.25	Managers' insights and intuition
11	3	2.88	Verification of correct software coding
12	2	2.25	Cost of getting results
13	2.5	2.50	Degree (magnitude) of effort developing results
14	3	2.75	Other program managers' acceptance of simulation results
15	2	2.38	Formal education courses in computer simulation
16	3	3.38	Tact used in presenting results

The second round of the Delphi exercise ended with consensus being achieved in fourteen of the sixteen Likert questions. This 87 percent consensus exceeds the 70 percent put forth in the previous chapter to determine closure, therefore the Delphi exercise was not carried into a third round.

A comparison of the medians for each factor, included in both survey rounds, shows that none of the values changed. This combined with the minor changes seen in the calculated Likert means indicate that no effective change in opinion took place during the two rounds. The ranking question, however, included a significant change in the "manager's insights and intuition" factor. This factor was moved up in the ranking six positions. This move indicates a definite change in the expert opinion between the two rounds. The move resulted in the factor being positioned more appropriately in comparison to the other factors and their medians. Most of the other factors were only changed by one or two positions, excluding the two new factors. These changes indicate minor adjustments, refinements, in the ranking and no substantive change in expert opinion is expressed. The second round ranking resulted in all factors with median of "strong effect" being in the top ten ranked positions. This shows that by the two evaluation techniques, Likert scale and ranking process, these factors have the most effect on the acceptance of computer simulation results. However, comparison of the top ten factors' mean and median values with the rankings suggest that the mean is not a good discriminator of importance within the group. The top three factors involve knowing the actual characteristics of the simulation, not the type of factor requiring the use of intuition or personal judgement. "Facts" are most important in accepting results.

The lower ranked factors, "11" through "16", appear to have considerably less effect on the acceptance of simulation results. A comparison of the calculated mean and median for the Likert questions, and the rankings supports this assertion.

The two new factors that were added as a result of the first round's comments had a definite impact on the rankings. The factor dealing with "user acceptance" was ranked number three and the factor addressing the acceptability of the model by the community that generally conducts simulations in the specialty area was ranked sixth out of the sixteen factors. This is a significant change from Morris' findings about the factors affecting the acceptance of industrial engineering recommendations. The difference seen in "user acceptance" is easily explained; Morris' research was centered on civilian industry where the company itself is the "user." There was no need to convince an outside agency of the model's accuracy. The second new factor can be described in much the same way as the first, however there is the added fact that in industrial companies most of the modeling and simulation effort is conducted by a central modeling office. In the situation where one central office conducts the simulations, there is no other "community" that conducts the simulations. The importance of these two factors on the Air Force manager's acceptance of computer simulation results show that the concerns and needs of the Air Force program manager are different than that of the manager in a civilian company. The civilian manager and the Air Force program manager do not make decisions using the same types of information. This statement is reinforced by the low importance of cost in the decision process.

Summary

This chapter reported the results of the research. The data presented was the result of a two round Delphi exercise. The exercise was terminated at the end of the second round. The first round survey was sent to twenty Air Force colonels with sixteen responding, an 80 percent response rate. From the sixteen responses, nine were qualified to participate in the second round of the survey. Of the nine sent the second round survey, eight responded yielding an 89 percent response rate. The Delphi exercise was terminated at the end of the second round with 87 percent of the questions achieving consensus. The first round of the survey resulted in the addition of two new factors to the second round. The second round ended with the top ten ranked factors, in Table 5, all reflecting a "strong effect" on the acceptance of computer simulation results. The remaining six factors show a smaller effect on simulation result acceptance. The final chapter presents the answers to the research questions and the effect of these answers.

IV. Conclusions and Recommendations

The DOD has stated, in a plan given to Congress, that simulation and modeling are essential to the "long term qualitative superiority of US weapon systems" (15:25). For these simulations and models to be useful two things must be true. First, the simulations and models must be accurate. If the simulations and models are not accurate, the erroneous results obtained will mislead decision makers and planners. Secondly, these simulations and models must be accepted by management. If the simulations and models are perfectly accurate, but the managers do not accept the results, they are not used by the organization. This research has focused on managerial acceptance of computer simulation results by senior program managers within AFSC.

In the area of simulation accuracy, there is a multitude of literature and research being performed. However, in the area of managers acceptance of simulation results, there is a noticeable lack of information currently available. This is even true in the most basic part of research, the determination of the factors affecting acceptance of computer simulation results. Robert Sargent has written on the topic of creating accurate simulations. He pointed out that the primary factor determining an individual's confidence in simulation is the degree of validation that has been performed (20:33,38). This can be applied to the manager's acceptance of simulation results as well. In addition to Sargent's writings, William Morris has written on managerial acceptance of industrial engineering recommendations. Morris agrees with Sargent that validity is a prime factor in managerial acceptance of information.

However, Morris also proceeded to outline eleven additional factors that need to be considered (14:16-19).

In light of the fact that no prior research with regard to Air Force program managers was found, this research is exploratory in nature. The Delphi survey technique of data collection was selected to identify the factors affecting acceptance of computer simulation results. The factors outlined by Sargent and Morris were used as the basis for this exploratory research.

The first round Delphi survey was sent to twenty Air Force colonels in job positions involving the acquisition of weapon systems. Sixteen of the colonels responded, however only nine were qualified to be a member of the expert panel. Only eight of the nine experts responded in the second round Delphi survey. A presentation of the survey results and their detailed analysis is presented in Chapter III of this document.

Limitations

The accuracy of the research presented is limited for several reasons. First, this research is the initial attempt to characterize the factors affecting the acceptance of simulation results, therefore duplication of these research results are not available. Through duplication of research, higher confidence is associated with the research results. Secondly, the number of the Delphi panel members was less than ten. In Delphi exercises where the panel has less than ten members, the results are considered to be less reliable than those with ten or more because of the restriction on differing opinions and experiences from which to draw. The next reason for limited accuracy in the research

results is the sampling technique used for this research. All of the experts were drawn from AFSC/ASD; no expert outside AFSC/ASD was considered for participation in the panel. The inclusion of experts outside of AFSC/ASD could have increased the diversity of background of the panel members as well as increased the number of experts participating.

Discussion

The information resulting from the Delphi exercise was sufficient to answer the two research questions presented in Chapter I. Each question is addressed in the following paragraphs.

The first research question was: What are the factors that affect the acceptance of computer simulation results used by senior program managers within AFSC/ASD? The answer to this question was determined through the use of the iterative feedback feature of the Delphi survey. Initially, Sargent's and Morris' factors were used to formulate the survey questions. The experts were then asked to suggest additional factors that affect acceptance. Two additional factors were identified through this process yielding a total of sixteen factors. The list of factors is shown in Table 6.

The second research question was: What is the relative importance of the factors identified to the senior program managers within AFSC/ASD? This question was answered through two techniques. The first technique involved evaluating the individual factors against a Likert scale. By taking the median of the Likert responses and comparing each against the other factors' median a relative importance can be determined. The second technique involved a rank ordering of the factors by each expert. This technique yielded a direct indication of relative importance. The

Table 6. Final Ranked Factors

Rank	Likert Median	Factor
1	4	Degree to which model represents the "real world"
2	4	Technical information incorporated in the computer model
3	4	Acceptance by user of the simulation's ability to represent the "real world"
4	4	Confidence in individual performing simulation
5	4	Ability to assimilate recommendations
6	4	Acceptability of model by the community that generally conducts simulations in the specialty area
7	4	Confidence in individual presenting results
8	4	Previous experience with simulations
9	4	Superior's acceptance of simulation results
10	4	Managers' insights and intuition
11	3	Verification of correct software coding
12	2	Cost of getting results
13	2.5	Degree (magnitude) of effort developing results
14	3	Other program managers' acceptance of simulation results
15	2	Formal education courses in computer simulation
16	3	Tact used in presenting results

result of these techniques are shown in Table 6. The results show that the top ten ranked factors also have the highest medians. The fact that both techniques are in agreement gives strong indication that the factors are correctly grouped together and that they are the primary influencing forces in the acceptance of simulation results. The remaining six factors also show good agreement between the Likert and ranking techniques. The ranking and medians indicate that these factors have a much lower influence on the acceptance of simulation results and, therefore, should not be regarded as heavily as the top ranked factors.

According to the research, for computer simulation results to be accepted by top management, the simulations must correctly represent the "real world" and the manager should agree with the technical information incorporated into the simulation. Additionally, he/she should believe the final user of the weapon system would accept the simulation as a good representation of the "real world" and the portion of the modeling community that generally conducts these simulations would also accept the models used. The manager himself must have confidence in the individual performing the simulation, be able to assimilate the recommendations resulting from the simulations and have confidence in the individual presenting the results. The manager also takes into consideration his/her prior experience with simulations, his/her superior's acceptance of simulation results, and his/her own personal insights and intuition.

It is obvious from this research that managers, according to the experts, will be more likely to use the results of computer simulations if those factors identified above are considered during model development. Model developers might want to consider a combination of actions to improve the use of simulation results. First, an evaluation of the

simulation's technical composition and accuracy should be performed. As part of this evaluation, the community that generally conducts the specific type of simulation should be consulted as to their views concerning the computer model under consideration for use. The result of this evaluation should then be presented to the decision makers involved. Secondly, the weapon system user, the SPO's customer, should be included in all phases of the computer modeling and simulation process. By involving the user early in the simulation effort, the user's needs and concerns can be taken into account; thereby increasing the overall acceptance of the simulation results. Next, select the individual(s) to perform the simulation on the basis of expertise in simulations and the specialty area to be simulated. Finally, individual(s) presenting information concerning the simulation or its results should have a thorough understanding of the facts surrounding the simulation effort and address only those results that have a direct bearing on the decision at hand.

Recommendations

The following recommendations are made for future research to better define the status of computer simulation utilization within Air Force weapon system procurement.

1. Research should be undertaken to replicate the results of this study. A second Delphi exercise should be performed using a larger number and a broader set of experts. The research should increase confidence in the factors arrived at in this thesis and identify other factors that may not have been introduced by this panel of experts. Follow-on Delphi exercises should probe experts from other AFSC product

divisions, other major commands and higher headquarters. By probing these varied groups, a generalized model of factors affecting acceptance of computer simulation results can be developed.

2. Research should be undertaken to determine the current level of acceptance of computer simulation results by managers Air Force wide. The sample should include individuals from various major commands, as well as acquisition and test organizations. The research should show any issues or problems that may exist and indicate where training and/or education is needed to improve and increase the usage of computer simulations by managers.

3. This thesis indicated that 44 percent of the managers surveyed had never used simulation results in decision making. Research should be undertaken to identify program managers who state they have never used computer simulation results in decision making. The research will include a determination as to the correctness of the statement as well as a determination of why computer simulation has not been used. This research should uncover areas where program managers are unknowingly using simulation results and those where the manager is intentionally avoiding the use of computer simulation results. In both instances, computer simulation results are not being used in the correct or most effective manner.

Summary

The thrust of this research was to determine the factors which contribute to the acceptance of computer simulation results. This determination was accomplished using the Delphi data collection tech-

nique with an expert panel of nine Air Force colonels assigned to AFSC/ASD.

The research found that sixteen factors exist that affect the acceptance of computer simulation results. The factors are presented in Table 3 of this chapter. Of these sixteen factors, ten factors had a "strong effect" according to a Likert scale rating of the factors.

Computer simulation can be a very effective tool in weapon system development and procurement, but only if managers are willing to accept the simulation results. It is this researcher's hope that the knowledge gained in this research will further the correct usage of computer simulation and will contribute to the development of more effective weapon systems for the USAF.

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT-PATTERSON AIR FORCE BASE OH 45433-6583

Appendix A: Round One Delphi Survey

11 May 1989

&NAME&
&OFFICE&
Wright-Patterson AFB, OH 45433-6583

Dear &NAME&:

AFIT is performing a Delphi survey. The purpose of this research is to determine the factors which affect managers' acceptance of computer simulation results. You have been selected to participate in this important research because your experience and insight qualify you as an "expert" in program management. Your opinions and comments will be combined with those of other "experts" to develop a descriptive model of factors affecting acceptance of simulation results.

The attached Delphi survey solicits your personal opinions in a number of areas. To assist in this research, please complete the survey and return it within 10 days. As soon as all the responses are compiled, a second survey will be sent to you.

Your comments, suggestions, and ideas regarding this research and the model are welcome and encouraged. If you have any questions about this survey please call me at (513) 255-3355 (AV:785-3355) or Captain Thomas Wiggs at (513) 255-5435 (AV:785-5435). Thank you for making time to share your expertise.

JOHN DUMOND, Lt Col, USAF
Head, Department of System
Acquisition Management
School of Systems and Logistics

2 Atchs
Delphi Survey
Envelope

STRENGTH THROUGH KNOWLEDGE

Round One Delphi Survey

1. Survey Objective:

To obtain expert opinion on what factors affect the managers' acceptance of computer simulation results.

2. General Comments:

a. The subject areas covered in this questionnaire are not meant to be complete or exhaustive. Instead, the coverage is designed to stimulate your thinking.

b. Your participation and honest opinions are key to the success of this research project. There are no right or wrong answers. Therefore, all your ideas and brainstorming comments should be included. In later rounds of questioning, these ideas may spark additional comments by other participants.

c. At least two rounds of questions will be needed to arrive at a group consensus. The first round should not take more than twenty minutes to complete. Each of the remaining one or two rounds should take less than thirty minutes. After each round, all participants' responses will be compiled and given back to you at the start of the next round. You will be provided an executive summary of this research after it is completed.

d. The questionnaire is divided into two sections. The first set of questions are inquires as to your personal background. The second set of questions address the issue of factors affecting managers' acceptance of computer simulation results.

e. The number in the upper right-hand corner of the questionnaire is for survey control purposes only. Please be assured that complete anonymity will be enforced.

3. Specific Instructions:

a. When the question calls for an answer along a scale, please circle the response which most accurately reflects your judgment on that question.

b. When a question requires a ranking response, please rank order the alternatives, using "1" for the most important item.

c. Please feel free to include the rationale for your answers, especially for those areas where you feel strongly. Add any illustrations, examples, or experiences you have had that will help the other participants understand your response. Feel free to write your comments on the back of the survey sheets. Please number your comments so they correspond to the question you are answering.

d. Any ideas or recommendations you have for improving the manager's acceptance of computer simulation results should also be included with your responses. Your ideas will be shared with others who care about the acceptance of simulation results.

e. The last page of this survey is for any additional comments you feel are pertinent to this study.

f. If you have any questions about this survey please call Capt Thomas Wiggs at (513) 255-5435 (AV: 785-5435) or LtCol John Dumond at (513) 255-3355 (AV: 785-3355).

THANK YOU FOR PARTICIPATING IN THIS SURVEY.

Section 1: Questions on your personal background.

1. What is your RANK/GRADE: ________

2. What was your major field of study for each degree:
(Place answer in the space provided next to each degree listed below)

A. Engineering
B. Liberal Arts
C. Sciences
D. Business Administration
E. Program Management
F. Other: ________________

Bachelor: _____
Masters: _____
Doctorate: _____

3. How many formal computer simulation courses have you taken:

______

4. How many years of System Program Office (SPO) experience do you have? (To the nearest year):

______

5. How many years of computer simulation experience do you have? Count the years of development, design and/or programming of simulations, as well as decision making based on simulations. (To the nearest year):

______

6. What major commands have you been assigned to:
(Mark all that apply)

A. SAC	C. MAC	E. AFLC	G. Other ______________
B. TAC	D. AFSC	F. AFCC	

7. Have you ever participated in the development a computer model?

__ YES __ NO

8. Have you ever used the results of a computer simulation in decision making?

__ YES __ NO

9. If the answer to both questions 7 and 8 above are NO, DO NOT GO ANY FURTHER. Please fold the questionaire, place it in the provided envelope and return to the address provided.

Section 2: Prior research has suggested that factors in the questions below may affect the acceptance of computer simulation results by managers. Please read each question and circle the answer that most accurately reflects your judgment on that question. Use the following scale:

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

10. What effect does a manager's understanding of the technical information used in simulations have on their acceptance of simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

11. What effect does the degree to which a computer model represents the "real world" have on a manager's acceptance of simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

12. What effect does the verification of correct software coding in the model used for simulation have on a manager's acceptance of simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

13. What effect does the simulation results' agreement with the manager's insights and intuition have on his/her acceptance of these results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

Comments:

14. What effect does the general acceptance of simulation results by a manager's superiors have on his/her acceptance of simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

15. What effect does the acceptance of simulation results by other program managers have on a manager's acceptance of simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

16. What effect does the degree (magnitude) of effort used in developing the simulation have on a manager's acceptance of the results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

17. What effect does the manager's ability to understand recommendations resulting from simulations have on his/her acceptance of the simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

18. What effect does a manager's confidence in the individual presenting the results have on his/her acceptance of simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

Comments:

19. What effect does confidence in the individual performing the simulation have on a manager's acceptance of simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

20. What effect does the cost of obtaining the simulation have on a manager's acceptance of simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

21. What effect does a manager's previous experience with simulation have on their acceptance of simulation results later?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

22. What effect does skill used in presenting the simulation results have on a manager's acceptance of these results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

23. What effect does formal education courses in computer simulation have on a manager's acceptance of simulation results?

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

Comments:

24. In the blanks to the <u>left</u> of each item, rank order the following items (1 being most important) as to what you feel has had the most impact on managers' acceptance of computer simulation results.

In the blanks to the <u>right</u> of each item, mark the items that managers require personal knowledge of, leaving blank those items that the manager does not care about or that may be the responsibility of individuals lower in the organizational structure.

RANK		PERSONAL KNOWLEDGE REQUIRED
_____	A. Technical information incorporated in the computer model	_____
_____	B. Degree to which model represents the "real world"	_____
_____	C. Verification of correct software coding	_____
_____	D. Managers' insights and intuition	_____
_____	E. Superior's acceptance simulation results	_____
_____	F. Other program managers' acceptance of simulation results	_____
_____	G. Degree (magnitude) of effort developing results	_____
_____	H. Ability to assimilate recommendations	_____
_____	I. Confidence in individual presenting results	_____
_____	J. Confidence in individual performing simulation	_____
_____	K. Cost of getting results	_____
_____	L. Previous experience with simulations	_____
_____	M. Tact used in presenting results	_____
_____	N. Formal education courses in computer simulation	_____

Comments:

Is there anything else you would like to add or any other factors you feel should be included?

Thank you for completing this questionnaire and sharing your opinions. Please send through distribution or mail this survey as soon as possible to:

AFIT/LSG (Bldg 641) (Capt Thomas Wiggs)
Wright-Patterson AFB, OH 45433-6583

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT-PATTERSON AIR FORCE BASE OH 45433-6583

Appendix B: Round Two Delphi Survey

21 June 1989

&NAME&
&OFFICE&
Wright-Patterson AFB, OH 45433-6583

Dear &NAME&:

Thank you for completing the first round of the AFIT Delphi survey on the factors affecting acceptance of computer simulation results. Your comments were of great value to this research.

The second round Delphi questionnaire containing respondent feedback is attached. Please read the comments and then answer the questions that follow. You will also note that the feedback provided for each question includes the frequency distribution of responses, plus your response on the last Delphi questionnaire. You may want to consider all the feedback in making your responses on this questionnaire.

Captain Wiggs and I appreciate the time you are investing in this research. Please try to return your completed survey within two weeks, so the responses can be analyzed and a third round begun in July, if needed. Thank you again for helping us learn more about the usage of computer simulation results.

JOHN DUMOND, Lt Col, USAF
Head, Department of System
Acquisition Management
School of Systems and Logistics

2 Atchs
Delphi Survey
Envelope

Round Two Delphi Survey

1. Survey Objective:

To obtain expert opinion on what factors affect the managers' acceptance of computer simulation results.

2. General Comments:

a. During this round you will be given the frequency distribution for all responses for each question directly above the descriptive terms. You will also have representative comments listed with the question for which it was given. This feedback is designed to provide some "food for thought" as you revisit these questions. You will have space to make further comments regarding this feedback.

b. Your participation and honest opinions are key to the success of this research project. There are no right or wrong answers. Therefore, all your ideas and brainstorming comments should be included.

c. The number in the upper right-hand corner of the questionnaire is for survey control purposes only. Please be assured that complete anonymity will be enforced.

3. Specific Instructions:

a. Please consider the feedback provided with each question before you respond to the question. Please note that as a result of round one there are two new factors which require evaluation.

b. When the question calls for an answer along a scale, please circle the response which most accurately reflects your judgment on that question.

c. When a question requires a ranking response, please rank order the alternatives, using "1" for the most important item. On question 17 you will be asked to show where the two new factors should be inserted into the order of importance.

d. Please feel free to include the rationale for your answers, especially for those areas where you feel strongly. Add any illustrations, examples, or experiences you have had that will help the other participants understand your response. Feel free to write your comments on the back of the survey sheets. Please number your comments so they correspond to the question you are answering.

e. Any ideas or recommendations you have for improving the manager's acceptance of computer simulation results should also be included with your responses. Your ideas will be shared with others who care about the acceptance of simulation results.

e. The last page of this survey is for any additional comments you feel are pertinent to this study.

f. If you have any questions about this survey please call Capt Thomas Wiggs at (513) 845-0652 or LtCol John Dumond at (513) 255-3355 (AV: 785-3355).

THANK YOU FOR PARTICIPATING IN THIS SURVEY.

Prior research has suggested that factors in the questions below may affect the acceptance of computer simulation results by managers. Please read each question and circle the answer that most accurately reflects your judgment on that question. Use the following scale:

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

1. What effect does a manager's understanding of the technical information used in simulations have on their acceptance of simulation results?

   YOUR ROUND 1 RESPONSE:

   COMMENTS: "Between moderate and strong - too often managers believe the data is being manipulated to get an answer if they don't understand the detail." (NOTE: Data point counted as a "Strong")

   ROUND 1 RESPONSES:

1	6	2	0	0	0
VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

2. What effect does the degree to which a computer model represents the "real world" have on a manager's acceptance of simulation results?

   YOUR ROUND 1 RESPONSE:

   COMMENTS: "Depends: many times we can only guess at 'real world' but the simulation is still valuable in choosing between alternatives, using the source set of assumptions, or a controlled set of variables."
   (NOTE: One panel member supplied two responses in connection with the above comment)

   ROUND 1 RESPONSES:

4	5	0	0	1	0
VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

Comments:

3. What effect does the verification of correct software coding in the model used for simulation have on a manager's acceptance of simulation results?

YOUR ROUND 1 RESPONSE:

COMMENTS: "Think the answer is little, but should be strong."

ROUND 1 RESPONSES:

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND
1	2	3	3	0	0

4. What effect does the simulation results' agreement with the manager's insights and intuition have on his/her acceptance of these results?

YOUR ROUND 1 RESPONSE:

COMMENTS: "Too often the model results are accepted only if they support intution."

"Unfortunately, we all suspect the model builder, because simulations have been used for political purposes; thus, and again unfortunately, simulations that counter our intution are often rejected."

ROUND 1 RESPONSES:

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND
3	[illegible]	2	0	0	0

Comments:

5. What effect does the general acceptance of simulation results by a manager's superiors have on his/her acceptance of simulation results?

YOUR ROUND 1 RESPONSE:

COMMENTS: NONE

ROUND 1 RESPONSES:

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND
1	4	4	0	0	0

6. What effect does the acceptance of simulation results by other program managers have on a manager's acceptance of simulation results?

YOUR ROUND 1 RESPONSE:

COMMENTS: NONE

ROUND 1 RESPONSES;

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND
0	1	4	4	0	0

7. What effect does the degree (magnitude) of effort used in developing the simulation have on a manager's acceptance of the results?

YOUR ROUND 1 RESPONSE:

COMMENTS: NONE

ROUND 1 RESPONSES:

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND
0	1	3	3	2	0

Comments:

8. What effect does the manager's ability to understand recommendations resulting from simulations have on his/her acceptance of the simulation results?

YOUR ROUND 1 RESPONSE:

COMMENTS: NONE

ROUND 1 RESPONSES:

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND
3	5	0	0	0	1

9. What effect does a manager's confidence in the individual presenting the results have on his/her acceptance of simulation results?

YOUR ROUND 1 RESPONSE:

COMMENTS: "The simulator better be able to defend every variable and assumption. Consistency and practicality are what I look for. Did he change his model for this simulation? If so why?"

ROUND 1 RESPONSES:

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND
2	6	1	0	0	0

10. What effect does confidence in the individual performing the simulation have on a manager's acceptance of simulation results?

YOUR ROUND 1 RESPONSE:

COMMENTS: "Consistency/Honesty"

ROUND 1 RESPONSES:

VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND
2	5	1	1	0	0

Comments:

11. What effect does the cost of obtaining the simulation have on a manager's acceptance of simulation results?

YOUR ROUND 1 RESPONSE:

COMMENTS: NONE

ROUND 1 RESPONSES:

0	0	4	3	2	0
VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

12. What effect does a manager's previous experience with simulation have on their acceptance of simulation results later?

YOUR ROUND 1 RESPONSE:

COMMENTS: NONE

ROUND 1 RESPONSES:

0	5	4	0	0	0
VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

13. What effect does skill used in presenting the simulation results have on a manager's acceptance of these results?

YOUR ROUND 1 RESPONSE:

COMMENTS: NONE

ROUND 1 RESPONSES:

0	3	6	0	0	0
VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

Comments:

14. What effect does formal education courses in computer simulation have on a manager's acceptance of simulation results?

YOUR ROUND 1 RESPONSE:

COMMENTS: NONE

ROUND 1 RESPONSES:

0	1	3	5	0	0
VERY STRONG EFFECT	STRONG EFFECT	MODERATE EFFECT	LITTLE EFFECT	NO EFFECT	NO OPINION/ DON'T UNDERSTAND

15. What effect does the acceptance by the user of the simulation's ability to represent the "real world" have on a manager's acceptance of simulation results?

*** New Question ***

VERY STRONG	STRONG	MODERATE	LITTLE	NO	NO OPINION/
EFFECT	EFFECT	EFFECT	EFFECT	EFFECT	DON'T UNDERSTAND

16. What effect does the acceptability of the model by the community that generally conducts simulations in the specialty area (for instance-- there are several ECM models, but none are widely accepted) have on a manager's acceptance of simulation results?

*** New Question ***

VERY STRONG	STRONG	MODERATE	LITTLE	NO	NO OPINION/
EFFECT	EFFECT	EFFECT	EFFECT	EFFECT	DON'T UNDERSTAND

Comments:

17. Given the results of round one, below, revise the rankings as needed.

To the <u>left</u> of each item is the ranking (1 being most important) as to what you feel has had the most impact on managers' acceptance of computer simulation results.

To the <u>right</u> of each item is the number of panel members that require personal knowledge of that factor when using simulation results. Items that did not require personal knowledge were assumed to be of no importance or were the responsibility of individuals lower in the organizational structure.

	RANK		PERSONAL KNOWLEDGE REQUIRED	
___	1	Degree to which model represents the "real world"	9	___
___	2	Technical information incorporated in the computer model	8	___
___	3	Confidence in individual performing simulation	5	___
___	4	Confidence in individual presenting results	4	___
___	5	Ability to assimilate recommendations	4	___
___	6	Previous experience with simulations	3	___
___	7	Superior's acceptance simulation results	5	___
___	8	Verification of correct software coding	1	___
___	9	Degree (magnitude) of effort developing results	2	___
___	10	Cost of getting results	3	___
___	11	Other program managers' acceptance of simulation results	1	___
___	12	Formal education courses in computer simulation	1	___
___	13	Tact used in presenting results	0	___
___	14	Managers' insights and intuition	8	___

For the two new factors, below, please indicate where within the updated prioritized list of factors, above, they should be placed.

A. "Acceptance by user of the simulation's ability to represent the 'real world.'"

Place between ____ and ____.

B. "Acceptability of the model by the community that generally conducts simulations in the specialty area. For instance- there are several ECM models, but none are widely accepted."

Place between ____ and ____.

Is there anything else you would like to add or any other factors you feel should be included?

"Acceptance by user of the simulation representing the real world."

"Acceptability of the model by the community that generally conducts simulations in the specialty area. For instance-there are several ECM models, but none are widely accepted."

(NOTE: Each of the above listed comments were included as new questions in this round of the survey.)

Thank you for completing this questionnaire and sharing your opinions. Please send through distribution or mail this survey as soon as possible to:

AFIT/LSG (Bldg 641) (Capt Thomas Wiggs)
Wright-Patterson AFB, OH 45433-6583

Appendix C: Delphi Survey Comments

1. What effect does a manager's understanding of the technical information used in simulations have on their acceptance of simulation results?

   ROUND 1 COMMENTS: "Between moderate and strong - too often managers believe the data is being manipulated to get an answer if they don't understand the detail."

   ROUND 2 COMMENTS: NONE

2. What effect does the degree to which a computer model represents the "real world" have on a manager's acceptance of simulation results?

   ROUND 1 COMMENTS: "Depends: many times we can only guess at 'real world' but the simulation is still valuable in choosing between alternatives, using the source set of assumptions, or a controlled set of variables."

   ROUND 2 COMMENTS: "Agree (with Round 1 comment - absolute numbers may be off with deltas still valid! However, a credible link to reality must exist."

   "I stay as before - when the model can represent the real world acceptance is strong - but there are cases where we simply do not know the real world. In this case, a disciplined approach to modeling the real world is still valuable to decision makers. Thus, the no effect answer - useful for testing hypotheses."

3. What effect does the verification of correct software coding in the model used for simulation have on a manager's acceptance of simulation results?

   ROUND 1 COMMENTS: "Think the answer is little, but should be strong."

   ROUND 2 COMMENTS: "Incorrect coding would introduce random 'unknown-unknowns' into results and further (greatly!) weaken credibility in results."

   "Agree with (Round 1) comment"

   "Managers have little time or even understanding of software verification; thus, I say little effect. Any other answer would be speaking to the ideal rather than real world."

4. What effect does the simulation results' agreement with the manager's insights and intuition have on his/her acceptance of these results?

ROUND 1 COMMENTS: "Too often the model results are accepted only if they support intuition."

"Unfortunately, we all suspect the model builder, because simulations have been used for political purposes; thus, and again unfortunately, simulations that counter our intuition are often rejected."

ROUND 2 COMMENTS: "Agree" (with Round 1 comment).

"Agree with comment in #4. Tough to overcome inherent biases."

"Managers are people. People have insights and intuition. Regardless of how rigorous the modeling effort or how convincing the modelers might be, the manager is still going to rely to some degree on his/her experience - i.e. intuition and insights."

"I'll stay with moderate:

a. When I use a model/modeler with whom I have experience and trust - I accept results that are contrary to intuition.
b. When I use an unknown model/modeler, I question unintuitive results for the reasons stated in your second comment."

5. What effect does the general acceptance of simulation results by a manager's superiors have on his/her acceptance of simulation results?

ROUND 1 COMMENTS: NONE

ROUND 2 COMMENTS: "If you have to support your decision up the chain and the boss does [not] accept simulations, why use them?"

6. What effect does the acceptance of simulation results by other program managers have on a manager's acceptance of simulation results?

ROUND 1 COMMENTS: NONE

ROUND 2 COMMENTS: "I changed because recently I've noticed more managers being swayed to some degree by others' opinions."

"If we were all talking about the same model and the same modeler, I might move to strong. Otherwise, I don't care what other PM think of simulations. They are valuable to see."

7. What effect does the degree (magnitude) of effort used in developing the simulation have on a manager's acceptance of the results?

ROUND 1 COMMENTS: NONE

ROUND 2 COMMENTS: "Let's be real, as a PM I don't care how hard it is to do a simulation. If the modeler can do it and the simulation is valuable to the decision process, we go for it. If it's not valuable to the decision we don't do it no matter what the effort is."

8. What effect does the manager's ability to understand recommendations resulting from simulations have on his/her acceptance of the simulation results?

ROUND 1 COMMENTS: NONE

ROUND 2 COMMENTS: NONE

9. What effect does a manager's confidence in the individual presenting the results have on his/her acceptance of simulation results?

ROUND 1 COMMENTS: "The simulator better be able to defend every variable and assumption. Consistency and practicality are what I look for. Did he change his model for this simulation? If so why?"

ROUND 2 COMMENTS: "Agree" (with Round 1 comment).

10. What effect does confidence in the individual performing the simulation have on a manager's acceptance of simulation results?

ROUND 1 COMMENTS: "Consistency/Honesty"

ROUND 2 COMMENTS: "Quite often, the manager has <u>no</u> idea who is running a simulation."

11. What effect does the cost of obtaining the simulation have on a manager's acceptance of simulation results?

ROUND 1 COMMENTS: NONE

ROUND 2 COMMENTS: "A credible presentation, well-prepared and skillfully presented, whether it's simulation results or something else, can strongly affect a manager's acceptance."

"<u>Cost</u> is a decision I make <u>before</u> I start. Once I have the results in hand, it is <u>too</u> <u>late</u> to make cost influence acceptance."

12. What effect does a manager's previous experience with simulation have on their acceptance of simulation results later?

ROUND 1 COMMENTS: NONE

ROUND 2 COMMENTS: NONE

13. What effect does skill used in presenting the simulation results have on a manager's acceptance of these results?

ROUND 1 COMMENTS: NONE

ROUND 2 COMMENTS: "The PM has got to understand what he is being told. If the presentation does not contribute to understanding how can there be acceptance?"

14. What effect does formal education courses in computer simulation have on a manager's acceptance of simulation results?

ROUND 1 COMMENTS: NONE

ROUND 2 COMMENTS: "I was strong because I believe the more you know about the capabilities/limitations of simulation as a management tool the better you can use them; but i've changed because I know PM's with no education who use them well."

15. What effect does the acceptance by the user of the simulation's ability to represent the "real world" have on a manager's acceptance of simulation results?

*** New Question on Round 2***

ROUND 2 COMMENTS: NONE

16. What effect does the acceptability of the model by the community that generally conducts simulations in the specialty area (for instance-- there are several ECM models, but none are widely accepted) have on a manager's acceptance of simulation results?

*** New Question on Round 2***

ROUND 2 COMMENTS: "Utility and integrity are important. If the community has rejected a model they must know something. Remember models are tools - not the answer. Why use a defective tool?"

Is there anything else you would like to add or any other factors you feel should be included?

ROUND 1 COMMENTS: "Acceptance by user of the simulation representing the real world."

"Acceptability of the model by the community that generally conducts simulations in the specialty area. For instance-there are several ECM models, but none are widely accepted."

ROUND 2 COMMENTS: "Track record of individual or organization performing the simulation."

"May already be included but it seems that official sanction by competent authorities designating the use of a simulation model for certain purposes enhances its acceptance in the larger community. For instance, I am thinking of the Logistics Composite Model (LCOM) which the Air Force Manpower Community has validated as the preferred model to conduct manpower analyses. As such it has maintained its credibility over time despite some obvious short comings."

"I am big on understanding the assumptions used before the simulation is run. Playing with assumptions can cause wide swings in the results; thus, if I disagree with or don't understand an assumption, seeing the simulation's sensitivity to that assumption often increases my acceptance of the results."

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VITA

Captain Thomas Kent Wiggs [redacted] He then attended Virginia Military Institute (VMI) from which he received a Bachelor of Science degree in Electrical Engineering in May 1981.

Upon graduation, he received a commission in the USAF through the ROTC program. Captain Wiggs reported for initial duty on June 27, 1981 at Offutt AFB, Nebraska assigned to the 544th Strategic Intellegence Wing (SIW) as a Minuteman III Ballistic Missile Trajectory Engineer. He then served as Chief, Advanced Cruise Missile Ground-Based Threat Test at Edwards AFB, California. In 1988 Captain Wiggs entered the Air Force Institute of Technology, School of Systems and Logistics, as a graduate student in Systems Management.

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Thesis Advisor: John Dumond, Lt Col USAF
Head, Department of System Acquisition Management
School of Systems and Logistics

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Larry W. Emmelhainz

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For the Air Force to continue developing and acquiring today's highly complex and costly weapon systems, it will have to depend more heavily on computer simulations to fill in where hardware is not available and actual testing cannot be performed. The usefulness of these computer simulations are limited, however, by the degree to which the results are accepted by managers. From a review of the literature, however, it would appear that no previous research has been performed to determine Air Force program managers' perceptions of the acceptability of computer simulation results. In light of that finding, the two objectives of this thesis were to identify the factors affecting the acceptance of computer simulation results by senior program mangers within AFSC/ASD and to determine the relative importance of the identified factors.

Because this research was exploratory in nature, the Delphi data collection technique was used. An expert panel of nine Air Force colonels completed the Delphi survey. The experts arrived at a list of sixteen factors that affect the acceptance of simulation results. Of these sixteen factors, only ten were said to have a "strong effect."

The conclusions drawn from the expert panel responses show that senior program managers are principally concerned about the simulation representing the "real world" and about the technical information incorporated into the model. The experts also expressed that the manager needs to know if the end user of the weapon system believes the simulation to be accurate. Several of the other factors included: confidence in the individual performing the simulation, ability to assimilate any recommendations, acceptability of the model by the community that generally conducts simulations in the specialty area, confidence in the individual presenting the results, previous experience with simulations, superior's acceptance of simulation results, and managers' own insights and intuition.